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BOTANY.—*New plants from Central America.*—VIII.

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The eighteen plants here described as new are chiefly Costa Rican, and the greater part of them are based upon material collected by the writer. Many of these new species belong to the Araceae and Bromeliaceae, families in which the Costa Rican flora is exceptionally rich. Worthy of special note is the new *Gynandropsis* described from Costa Rica. This plant is strikingly beautiful because of its red flowers, and is well worthy of cultivation for ornamental purposes.

Anthurium tilaranense Standl., sp. nov.

Plant epiphytic, the caudex very short or elongate, the internodes abbreviated, the cataphylls weathering into coarse persistent fibers; petioles 15–20 cm. long, slender, shallowly sulcate on the upper side, geniculate 1.5–2 cm. below the base of the blade; leaf blades firm-coriaceous, green, glabrous, deeply 3-lobed to within 3.5 cm. of the base, 16–22 cm. long and of equal or greater breadth, the basal lobes 11–14 cm. long, oblong, 2.5–4 cm. wide, rounded at apex, convex on the lower margin, concave on the inner, the terminal lobe narrowly oblong, 16–22 cm. long, 3–5.5 cm. wide, abruptly narrowed to the cuspidate-acuminate apex, the 2 basal nerves divergent at an angle of about 80 degrees, margined to the base, the secondary nerves of the terminal lobe about 17 on each side, ascending at an acute angle, anastomosing remote from the margin to form a conspicuous collective nerve, all the nerves slender but prominent beneath; peduncles 7–15 cm. long; spathe oblong or ovate-oblong, 3–7 cm. long, 1.2–2.5 cm. wide, green, rounded and cuspidate at apex, united for about 1.5 cm. with the peduncle; spadix sessile, cylindric, rounded at apex, very densely many-flowered, 4–7 cm. long, 6–12 mm. thick, green or reddish.

[1] Published by permission of the Secretary of the Smithsonian Institution. For the last preceding paper of this series see page 159 of this volume of THE JOURNAL. Received March 23, 1927.

Type in the U. S. National Herbarium, no. 1,254,577, collected on tree in moist forest at Quebrada Serena, southeast of Tilarán, Guanacaste, Costa Rica, altitude about 700 meters, January 27, 1926, by Paul C. Standley and Juvenal Valerio (no. 46310). Collected also at Los Ayotes, near Tilarán, *Standley & Valerio* 45586.

In general appearance as well as in technical characters this plant resembles Engler's illustration[2] of *A. denudatum* Engler, a Colombian species. In that, however, the leaves are essentially different, the lateral lobes being reflexed rather than directed forward, as in the Costa Rican plant. *Anthurium tilaranense* is strikingly different in foliage characters from any other species known from Central America.

Anthurium hypoleucum Standl., sp. nov.

Petioles about 18 cm. long and nearly 1 cm. thick, shallowly sulcate above, geniculate at apex; leaf blades narrowly lance-oblong, 47–55 cm. long, 11–13 cm. wide, narrowed from below the middle to the obtuse apex, rounded at base, thick-coriaceous, green above, glaucous beneath, the costa very stout and prominent, the main lateral nerves slender but prominent, about 22 on each side, anastomosing to form a conspicuous collective nerve about 1 cm. from the margin; peduncle 30–50 cm. long, stout; spathe green, ovate-oblong, 2.5–4 cm. long, 1.5–2 cm. wide, cuspidate-acuminate; spadix in anthesis cylindric, sessile, slightly narrowed upward, 5.5 cm. long, 9 mm. thick, very densely many-flowered.

Type in the U. S. National Herbarium, no. 932125, collected on rocks at Santa Rosa, Guatemala, altitude 1,600 meters, April, 1908, by H. von Tuerckheim (no. II.2214). Collected also at Mazatenango, Guatemala, November, 1914, *R. Tejada* 306.

The strongly glaucous lower surface of the leaves is a character not found in any other Central American *Anthurium* with which I am familiar.

Pitcairnia Valerii Standl., sp. nov.

Leaves unknown, only the inflorescence at hand; inflorescence paniculate, long-stalked, the panicle about 60 cm. long, twice branched, glabrous throughout, the branches few, the lowest about 17 cm. long; rachises slender, smooth, terete, many-flowered, the internodes 4–10 mm. long; primary bracts withered and fallen; bractlets lanceolate, greenish, scarious-margined, much shorter than the pedicels, their margins free but often involute about the pedicel; pedicels 5–7 mm. long, the flowers deflexed; inferior portion of ovary turbinate, 4–5 mm. long, usually bluntly verruculose; sepals lanceolate, about 9 mm. long and 3 mm. wide, long-acuminate, green, glumaceous, with scarious margins; petals eligulate, linear, 2 cm. long, red, obtuse or acutish; stamens slightly shorter than the petals; stigmas exceeding the petals; free portion of the capsule lanceolate, 1.5 cm. long, subulate-attenuate; seeds very numerous, brownish, filiform, about 6 mm. long.

Type in the U. S. National Herbarium, no. 1,306,886, collected on steep bank at La Hondura, Province of San José, Costa Rica, altitude about 1,500 meters, March 9, 1926, by Juvenal Valerio (*Standley* 51879).

[2] Pflanzenreich IV. **23B**: 263. 1905.

The plant grew in such a difficult situation that the leaves could not be reached, and it was only with considerable risk that the inflorescence was secured. The species belongs to Mez's section *Eligulatae*, and is perhaps related to *Pitcairnia nuda* Baker, of British Guiana.

Pitcairnia flaviflora Standl., sp. nov.

Plants terrestrial or epiphytic; petioles about 25 cm. long, slender, the margins densely armed below with slender, divaricate, dark brown spines 2–3 mm. long, the upper part of the petiole with few distant minute teeth; leaf blades oblanceolate, about 65 cm. long and 9.5 cm. wide, acute, long-attenuate to the base and decurrent upon the petiole, thin, glabrous or nearly so; inflorescence about a meter high, simple, the flowers secund, sessile or on very short, thick pedicels, forming a dense spike 30 cm. long, the rachis obscurely tomentose; bracts large, soon withering, membranaceous, slightly tomentulose, covering the buds; sepals distinct, symmetric, equal, lanceolate, 3 cm. long, thick, long-attenuate to a subulate tip, dark red, slightly tomentulose above; petals orange, glabrous, narrowly spatulate, 4.5 cm. long, 8–11 mm. wide, near the base 4 mm. wide, obtuse or rounded at apex, eligulate; filaments 3.3 cm. long, the anthers 1 cm. long.

Type in the U. S. National Herbarium, no. 1,226,103, collected at La Palma, Province of San José, Costa Rica, altitude about 1,600 meters, February 3, 1924, by Paul C. Standley (no. 33091).

The orange color of the petals distinguishes this species from most of those known from Central America.

Tillandsia guanacastensis Standl., sp. nov.

Plants epiphytic, solitary, 15–17 cm. high, the scape 7–9 cm. long; leaves very numerous, densely rosulate, the inner ones 7–18 cm. long, the outer shorter, erect or recurved, somewhat inflated at base, the sheaths 2–3 cm. wide, abruptly or gradually narrowed into the long-attenuate blades, subulate at apex, grayish, densely covered with closely appressed scales; inflorescence equaling or slightly surpassing the leaves, flabellate, composed of 2 or 3 clustered spikes; spikes 3–5 cm. long, 12 to 19-flowered, dense, distichous, the bracts and flowers inserted obliquely; bracts coriaceous, about 4 mm. long, green, rounded on the back, sparsely whitish-lepidote, obtuse or rounded at apex, shorter than the sepals; flowers sessile; sepals broadly elliptic, asymmetric, 5 mm. long, rounded at apex, glabrate but very sparsely and obscurely lepidote; capsules cylindric, 18 mm. long and 2.5 mm. thick, apiculate; seeds pale brown, 2 mm. long, the hairs white, 1 cm. long.

Type in the U. S. National Herbarium, no. 1,254,424, collected in moist forest at La Tejona, north of Tilarán, Guanacaste, Costa Rica, altitude about 650 meters, January 25, 1926, by Paul C. Standley and Juvenal Valerio (no. 46045). Collected also in the same general region, at Naranjos Agrios, *Standley & Valerio* 46391.

Closely related to *T. Tonduziana* Mez, also Costa Rican, but in that species the inflorescence is pinnate and much elongate, and the sepals and bracts coarsely brown-furfuraceous.

Tillandsia orthiantha Standl., sp. nov.

Plants epiphytic, solitary, about 30 cm. high, acaulescent; leaves numerous, densely rosulate, mostly 20–28 cm. long, erect or ascending, conspicuously inflated at base; sheaths about 7 cm. long and 5.5 cm. wide, brown, thin, abruptly contracted into the blades, these 1.5–2 cm. wide just above the sheath, long-attenuate to a slender involute-subulate tip, grayish, densely covered with minute, whitish, closely appressed scales; inflorescence exceeding the leaves, the cauline bracts loosely inflated, much exceeding the internodes, erect; inflorescence twice pinnate, 7–8 cm. long, dense, the primary bracts ovate, 2–3 cm. long, equaling or exceeding the spikes, acuminate, thin, brown, densely and coarsely brown-furfuraceous; spikes approximate, 6–10, distichous, about 12 mm. wide and 2 cm. long or shorter, 3 to 8-flowered, the flowers and bracts obliquely inserted, the spikes erect or strongly ascending; bracts 5–7 mm. long, shorter than the sepals, obtuse, rigid, brown-furfuraceous; sepals asymmetric, oval, 5 mm. long, rounded at apex, rigid, brown-furfuraceous, the inner one keeled dorsally; capsule terete, 2 cm. long, subulate-acuminate, glabrous, the valves 5 mm. wide; seeds brown, 1.5–2 mm. long, the white hairs 1.5 cm. long.

Type in the U. S. National Herbarium, no. 1,252,715, collected in wet forest at Laguna de la Chonta, northeast of Santa María de Dota, Province of San José, Costa Rica, altitude 2,100 meters, December 18, 1925, by Paul C. Standley (no. 42312). No. 42348, from the same locality, represents the same species.

This *Tillandsia*, also, is close to *T. Tonduziana* Mez, but in that the pinnate inflorescence is elongate and open, its rachis flexuous (not thick and straight, as in *T. orthiantha*), and the branches usually reflexed.

Renealmia erythrocarpa Standl., sp. nov.

Plants small, 60–120 cm. high, slender, leafy, the stems solitary or clustered, arising from slender rootstocks; lowest sheaths without blades, somewhat puberulent; upper sheaths glabrous or nearly so, nerved, the auricles extended about 2 mm. beyond the sheath; naked portion of the petiole about 1 cm. long; leaf blades small, lance-oblong, 11–16 cm. long, 2–4 cm. wide, long-acuminate, acute at base, thin, green on both surfaces, glabrous; panicles several, rising from the rootstock, ascending, the slender peduncle 5.5 cm. long, the bracts suberect, 1.5 cm. long, the inflorescence 2–3 cm. long, densely few-flowered, the rachis slightly flexuous, hirtellous, the bracts lanceolate, 1–1.5 cm. long, green, hirtellous, attenuate; flower clusters 2 or 3-flowered, the pedicels 2–3 mm. long; calyx in fruit about 7 mm. long, puberulent; fruit scarlet, lanceolate in outline, glabrous, about 18 mm. long and 6 mm. thick near the base, attenuate to the apex, finely costate; seeds about 12, truncate at one or both ends, grayish, about 3 mm. long.

Type in the U. S. National Herbarium, no. 1,254,613, collected in moist forest at Naranjos Agrios, near Tilarán, Guanacaste, Costa Rica, altitude about 700 meters, January 29, 1926, by Paul C. Standley and Juvenal Valerio (no. 46373).

Related to *R. humilis* (A. Rich.) Peters., which has been found in Panama, but in that species the leaves are much narrower, and the globose fruit scarcely half as long and few-seeded.

Renealmia concinna Standl., sp. nov.

Plants 1.5 m. high or smaller; leaf sheaths scaberulous-puberulent, many-nerved, the petioles usually obsolete; leaf blades oblanceolate, 30–50 cm. long, 5.5–7.5 cm. wide, acute or acuminate, long-attenuate to base, thin, green and glabrous above, beneath slightly paler, sparsely and minutely pilose with slender spreading hairs; panicles erect, arising from the base of the plant, the peduncle slender, 9 cm. long or more, pubescent, the bracts erect, scarious, much shorter than the internodes; inflorescence 13 cm. long and 2–3 cm. broad, interrupted, the rachis puberulent, the bracts oblong-ovate to lanceolate, 1–1.5 cm. long, thin, puberulent, deciduous, inconspicuous; flower clusters dense, 4 or 5-flowered, the peduncle 2–3 mm. long, the bractlets ovate, acute, about 8 mm. long, the pedicels puberulent, in fruit up to 5 mm long; calyx green, 5 mm. long, puberulent, the 3 lobes rounded; fruit globose, 7 mm. long, red, costate, thinly puberulent; seeds about 4, 3–4 mm. long, very irregular, brown.

Type in the U. S. National Herbarium, no. 1,227,906, collected in wet forest at Guápiles, Province of Limón, Costa Rica, altitude about 300 meters, March 12, 1924, by Paul C. Standley (no. 37355). No. 37511 from the same locality belongs to the same species.

Renealmia mexicana Klotzsch is closely related, but differs in its more lax inflorescence, glabrous ovary, and more numerous seeds.

Renealmia densiflora Standl., sp. nov.

Plants large, 1.5–2.5 m. high; leaf sheaths brownish, thin, many-nerved, minutely puberulent or glabrate; petioles obsolete; leaf blades oblong-obovate, 25–60 cm. long, 9–17 cm. wide, rounded and caudate-cuspidate at apex, acute at base, thin, green and glabrous above, slightly paler beneath and minutely pilose; inflorescence arising from the base of the plant, erect, 35–90 cm. high, the peduncle finely pubescent, stout, striate, the sheaths broad, inflated, rounded at apex, puberulent, erect, shorter than the internodes, often less than half as long; panicles cylindric and very dense, 7–14 cm. long, 3–4.5 cm. thick, the bracts reniform or rounded-ovate, about 1.5 cm. long and usually broader, rounded or apiculate at apex, green, firm, puberulent or glabrate, persistent; flower clusters sessile, few-flowered, very dense, the flowers sessile or nearly so; bractlets lance-oblong; ovary densely puberulent; calyx red, 6 mm. long, deeply 3-lobed, the lobes ovate, obtuse, puberulent or glabrate; fruit subglobose, glabrate, 5–6 mm. long, finely costate; seeds 6, subglobose, brown, 2.5 mm. long.

Type in the U. S. National Herbarium, no. 1,227,705, collected in wet forest at La Colombiana Farm, Province of Limón, Costa Rica, altitude about 70 meters, March 7, 1924, by Paul C. Standley (no. 36944). The following additional collections are referred here:

PANAMA: Around Dos Bocas, Río Fató Valley, Province of Colón, alt. 40–80 m., *Pittier* 4213. Forests around Puerto Obaldía, San Blas coast, at sea level, *Pittier* 4327.

Renealmia exaltata L.f. is distinguished from the present plant by its larger size, ampler inflorescence, and the very large bracts of the scape. *R. mexicana* Klotzsch is similar in habit, but has an open inflorescence, glabrous ovary, and more numerous seeds.

Pittier reports the vernacular name "mata Andrea" from Puerto Obaldía.

Calathea cleistantha Standl., sp. nov.

Leaves all arising from a short thick rootstock; sheaths 18 cm. long, narrow, green, glabrous, attenuate to apex; petioles about 4.5 cm. long, slender, glabrous; leaf blades elliptic-oblong, asymmetric, about 25 cm. long and 9.5 cm. wide, abruptly, obliquely, and shortly cuspidate-acuminate, acute at base and abruptly decurrent upon the petiole, thin, green on both surfaces, glabrous; spikes ascending, about 3 cm. long and 1.5 cm. broad, arising directly from the rootstock on a peduncle 1.5 cm. long, this covered by the large thin bracts borne at its base; bracts of the spike about 5, erect, crowded, ovate or lance-ovate, acuminate, about 3 cm. long, whitish, glabrous or nearly so, somewhat distichous; flowers 4 in each bract, sessile, the bractlets linear, 2.5 cm. long; ovary glabrous; sepals linear, glabrous, 2.5 cm. long; corolla dark red-purple, 3 cm. long.

Type in the U. S. National Herbarium, no. 1,229,179, collected in wet forest near Guápiles, Province of Limón, Costa Rica, altitude about 400 meters, March 12, 1924, by Paul C. Standley (no. 37114).

I have seen no material of *C. Pittieri* Schum., described from the same general region but, judging from the description, it is closely related to the present plant. *C. Pittieri* is described as being much larger, more than a meter high, with decumbent spikes having internodes as much as 5 cm. long.

Calathea marantifolia Standl., sp. nov.

Plants small, about 60 cm. high, very slender, leafy, the leaves about 6; sheaths green, thin, slightly puberulent or glabrate, attenuate to apex; petioles slender, 7 cm. long or less, glabrous, the callous 1.5 cm. long; leaf blades lance-oblong, about 19 cm. long and 4.5 cm. wide, acuminate, at base acute, thin, green on both sides, very minutely puberulent beneath, especially on the costa; leaf at base of the inflorescence sessile except for the callous, the blade 12 cm. long; spike ellipsoid, 2.3 cm. long, 1.5 cm. wide, the peduncle 9 cm. long, puberulent above; bracts about 5, spirally arranged, yellowish green, appressed-pilose, about 18 mm. long, rounded at apex, finely nerved.

Type in the U. S. National Herbarium, no. 1,254,038, collected in wet forest at El Arenal, Province of Guanacaste, Costa Rica, altitude 485 meters, January 18, 1926, by Paul C. Standley and Juvenal Valerio (no. 45310).

This may be only a reduced form of *C. macrosepala* Schum., but that is normally much larger in all its parts, with proportionately broader leaves and more numerous bracts.

Stellaria nubigena Standl., sp. nov.

Prostrate or procumbent perennial, forming loose clumps or mats, the stems numerous, slender, 4–15 cm. long, glabrous, often densely leafy, the internodes 5–15 mm. long; leaves narrowly lance-oblong to oblanceolate-oblong, 6–12 mm. long, 2–4 mm. wide, acute, with a somewhat callous tip, sessile or often narrowed to a short petiole-like base, thick and firm, 1-nerved, the costa stout, salient beneath, glabrous, but the petioliform base frequently villous-ciliate, sometimes densely so; flowers mostly axillary and solitary, sometimes in 2 or 3-flowered cymes, the pedicels erect or ascending, 7–10 mm. long, glabrous; sepals 5, narrowly lance-oblong, 2 mm. long (in fruit nearly 3 mm. long), attenuate-acuminate, glabrous, stiff, erect, green, the margins

scarious and whitish; petals white, shorter than the sepals; styles 3; capsule ovoid, obtuse, equaling the sepals, 6-valvate, the margins of the valves recurved; seeds about 10, reniform-globose, slightly compressed, brown, granular.

Type in the U. S. National Herbarium, no. 1,229,094, collected on wet bank on the southern slope of Turrialba Volcano, near the Finca del Volcán de Turrialba, Costa Rica, altitude about 2,300 meters, February 22, 1924, by Paul C. Standley (no. 35344). The following collections also are referable to this species:

COSTA RICA: Las Nubes, Province of San José, alt. 1,500–1,900 m., *Standley* 38736, 38829, 38784.

Only four other species of *Stellaria* are known from Central America. All of them differ from the plant here described in having ovate to deltoid leaves and villous or glandular pedicels.

Sisymbrium costaricense Standl., sp. nov.

Coarse erect annual, about a meter high, glabrous throughout (so far as specimens show; base of plant not seen), much branched, the branches green, terete, smooth; leaves sessile and clasping by a deeply cordate base, the auricles rounded; stem leaves lance-oblong, the largest 16 cm. long and 3 cm. wide, the upper much reduced, long-attenuate to the obtuse or acutish apex, finely, inconspicuously, and irregularly denticulate, deep green above, glaucescent beneath; racemes very long, laxly flowered; pedicels in anthesis 2–3 mm. long, in fruit up to 6 mm. long, stout, spreading or obliquely ascending, only the lowest subtended by leaflike bracts, the others naked; sepals oval-oblong, obtuse, 2.5 mm. long, green, with thin purplish margins; petals oblong, whitish, scarcely equaling the sepals; stamens shorter than the petals; pods sessile, 2.5–3 cm. long, over 1 mm. thick, straight, standing at almost a right angle to the rachis, the beak 2 mm. long; seeds compressed, pale brown.

Type in the U. S. National Herbarium, no. 1,252,847, collected in moist thicket near El Copey, Province of San José, Costa Rica, altitude about 2,000 meters, December 22, 1925, by Paul C. Standley (no. 42548). The following collections also may be cited:

COSTA RICA: Cornfields near El Copey, alt. 1,800 m., *Tonduz* 12190.

PANAMA: In coffee plantation near El Boquete, alt. 1,200–1,300 m., *Pittier* 3058.

At one time I referred this plant to *S. turritoides* Loes., a Mexican species, but better material shows that it is clearly distinct. *S. turritoides* has longer, nearly erect pods and larger flowers.

Sisymbrium guatemalense Standl., sp. nov.

Plants glabrous (lower part of plant not seen), the branches terete, smooth, tinged with purple; cauline leaves longer than the internodes, sessile and clasping by a deeply cordate base, the auricles rounded, the blades thin, oblong, about 6 cm. long and 1.2 cm. wide, the uppermost smaller, acute or short-acuminate, remotely and minutely repand-denticulate, green above, glaucescent beneath; racemes naked, elongate, rather densely flowered; pedicels 4–6 mm. long, slender, divaricate or slightly ascending; sepals oval, obtuse, 2 mm. long, purplish; petals shorter than the sepals; stamens equaling the sepals; pods strongly ascending, straight or slightly incurved, terete,

8–15 mm. long, slightly over 1 mm. thick, narrowed at apex to a beak 1 mm. long, attenuate at base to a stipe 1 mm. long.

Type in the U. S. National Herbarium, no. 354938, collected at San Miguel Uspantán, Department of Quiché, Guatemala, altitude 2,000 meters, April, 1892, by Heyde and Lux (no. 3079).

Although related to *S. turritoides* and *S. costaricense*, this differs conspicuously in the very short pods, which are contracted into a stipelike base.

Cleome panamensis Standl., sp. nov.

Slender erect annual herb, about 30 cm. high, sparsely branched, the stems glabrate below, sparsely glandular-pilose above, the hairs short and inconspicuous; infra-axillary prickles 2 below each petiole base, yellowish, divaricate or recurved, scarcely 1 mm. long; leaves 3-foliolate, the petioles very slender, 2.5–6 cm. long, sparsely and minutely glandular-pilose; leaflets subequal, sessile or short-petiolulate (petiolule of terminal leaflet sometimes 3.5 mm. long), elliptic or obovate, 3–6 cm. long, 1.5–2.7 cm. wide, short-acuminate at apex or rounded and apiculate, the terminal leaflet acute at base, the lateral ones oblique, rounded on the outer side, very acute on the inner, thin, sparsely pilose along the nerves with short stiff spreading hairs, glabrate above, beneath paler, often with 1 or 2 minute weak prickles on the costa; racemes short-pedunculate, few-flowered, lax, in age as much as 5 cm. long, the bracts large and leaflike, the lowest 3-foliolate, the others simple, petiolate, the rachis sparsely glandular-pilose; pedicels in fruit 1.5 cm. long or less, very slender; flowers greenish, the sepals 2.5 mm. long, obtuse or acute, glabrous; petals 5 mm. long, short-clawed; gynophore glabrous, 3–4 mm. long; capsule terete, torulose, 4.5 cm. long, 2.5–3 mm. thick, glabrous, acute at base, long-beaked at apex; seeds globose-reniform, 2 mm. in diameter, pale brownish, smooth.

Type in the U. S. National Herbarium, no. 678347, collected at Marragantí, Panama, April 5, 1908, by R. S. Williams (no. 993). An imperfect specimen from Quiriguá, Guatemala (*Standley* 24290), probably is referable to the same species.

The most closely related species is *C. aculeata* L., which differs in having coarsely tuberculate and transverse-ridged seeds.

Gynandropsis chiriquensis Standl., sp. nov.

A large coarse herb or shrub, the branches thick, succulent, green, at first densely viscid-villous with short hairs and coarsely viscid-puberulent, finally glabrate; petioles slender, 9–16 mm. long, at first pubescent like the branches but soon glabrate; leaflets usually 7, unequal, oblong-lanceolate, mostly 6–19, cm. long and 1.2–3.8 cm. wide, long-attenuate to the acuminate apex, acute or attenuate at base, petiolulate, the petiolules 1 cm. long or shorter, dilated at base and united to form a disk, deep green above and sparsely viscid-puberulent, paler beneath, viscid-puberulent on the nerves; racemes short-pedunculate, naked, very dense, many-flowered, the rachis about 4 cm. long, puberulent, the pedicels slender, 9–14 mm. long, sparsely and minutely puberulent or glabrous; flowers nearly all sterile, no fertile ones seen; sepals unequal, lanceolate or lance-oblong, the larger ones 6–7 mm. long, narrowed to an obtuse apex, glabrous, green, with reddish margins; petals red, about 13 mm. long, glabrous, the blade obovate, rounded at apex, narrowed at base

to a long claw; stamens 6, 2.5 cm. long, glabrous, the anthers linear-oblong, 3 mm. long; androphore 2.5 mm. long.

Type in the U. S. National Herbarium, no. 1,269,418, collected along the Caldera River below Quiel, Chiriquí, Panama, March 16, 1911, by H. Pittier (no. 3145).

According to description, this plant is closely related to the Colombian *G. coccinea* Benth., of which no material is available for comparison. That species is described as glabrous, a term certainly not applicable to the present plant. The sepals also are described as smaller, and the androphore as longer.

Gynandropsis pulcherrima Standl., sp. nov.

Plants herbaceous or somewhat woody, 1–3 m. high, simple or sparsely branched, the young branches green, somewhat villosulous above, especially at the bases of the petioles, but soon glabrate; leaves 3-foliolate, the petioles slender, mostly 9–18 cm. long, sordid-puberulent or glabrate, usually roughened with minute whitish verruculose elevations; leaflets sessile or nearly so, lance-oblong to oblong-elliptic, 10–20 cm. long, 4–9 cm. wide, acuminate, acute or cuneately narrowed at base, the lateral leaflets oblique, green above, slightly paler beneath, usually puberulent beneath on the veins, elsewhere glabrous; racemes terminal or opposite the leaves, short-pedunculate, the rachis stout, 6 cm. long or shorter, covered with the large dense elevated scars left by the fallen pedicels, only a few flowers open at one time; flowers mostly sterile, only a few of the lower ones fertile (very often none of the flowers of a raceme fertile); pedicels slender, mostly 1.2–2 cm. long, glabrate; sepals very unequal, 5–10 mm. long, narrowly oblong to ovate, obtuse or acute, glabrate, green, sometimes red-margined; petals obovate, long-clawed, rounded at apex, glabrous, mostly 1.5–2 cm. long, varying from bright red to salmon or pinkish; torus 3–6 mm. long; stamens 6, about 3 cm. long, the anthers 3–3.5 mm. long; fruit terete, 7–13 cm. long, 6–12 mm. thick, fleshy, usually red, glabrous, obtusely contracted at apex, the stout style 2–3 mm. long, the stipe about 2 cm. long.

Type in the U. S. National Herbarium, no. 1,253,694, collected in wet forest near Tilarán, Guanacaste, Costa Rica, altitude about 650 meters, January, 1926, by Paul C. Standley and Juvenal Valerio (no. 44560). The following collections are referred here:

COSTA RICA: El Arenal, Guanacaste, alt. 500 m., *Standley & Valerio* 45103. Quebrada Serena, Guanacaste, alt. 700 m., *Standley & Valerio* 46159, 46222. La Hondura, Province of San José, alt. 1,500 m., *Standley* 37605. Las Nubes, Province of San José, *Standley* 38576. Near Finca La Cima, north of El Copey, Province of San José, *Standley* 42563, 42621. Santa María, Province of San José, alt. 1,600 m., *Standley & Valerio* 43129, 44101. Orosi, Province of Cartago, *Standley* 39741, 39827. La Estrella, Province of Cartago, *Standley* 39209.

This plant is frequent in the mountain forests of Costa Rica, although seldom abundant. It is one of the most handsome and showy plants of the region.

Capparis Pittieri Standl., sp. nov.

Branchlets green, subterete, when young finely stellate-pubescent but soon glabrate; petioles thick and stout, 3–4 mm. long, glabrate; leaf blades oblong,

7.5–17 cm. long, 3–7.5 cm. wide, abruply short-acute, obtuse or rounded at base, subcoriaceous, when young closely stellate-tomentose on the upper surface but soon glabrous, the venation prominent, beneath paler, thinly stellate-pubescent with minute inconspicuous hairs; peduncles terminal, slender, 1.5–3 cm. long, finely stellate-pubescent, usually 3-flowered, the pedicels slender, erect, 1.7–2.5 cm. long, minutely stellate-tomentose with pale brownish hairs; sepals elliptic-oblong, 4–5 mm. long, obtuse, open in bud, stellate-tomentose; petals elliptic-oblong, 7–8 mm. long, obtuse or acutish, acute at base, sessile, thinly stellate-pubescent outside with whitish hairs; stamens numerous, the filaments very long and slender, glabrous, the anthers 1.5 mm. long; ovary ellipsoid, 2.5 mm. long, glabrous, the slender gynophore about 4 cm. long, glabrous.

Type in the U. S. National Herbarium, no. 578070, collected at Río Hondo, Costa Rica, altitude 50 meters, February 15, 1903, by H. Pittier (no. 16648).

This well-marked species is not closely related to any known from Central America. The specimens have been determined as *C. filipes* Donn. Smith, but that species, with its narrow, long-acuminate leaves, silvery-tomentose beneath, and its pendent inflorescence, has little in common with *C. Pittieri*.

BOTANY.—*Some Mimosaceae from Hispaniola.*[1] J. N. Rose and E. C. Leonard, U. S. National Museum.

Study of recent collections of *Mimosa* from Hispaniola resulted in the discovery of several little-known species and led us to revise this genus as represented in Hispaniola. There are now 7 recognized mimosas on the island, and one additional species still referred here which doubtless belongs elsewhere. This species, *M. angustifolia* Lam., was described rather fully in 1783, but so far as we can learn has not again been collected.

A new species of *Pithecolobium* has also been discovered among Dr. Abbott's collections.

In this connection we should like to call attention to the fact that there are ascribed to Hispaniola a number of Mimosaceae procured by the older collectors, which have not been found in recent times. One of these is *Inga filipes* Vent., described in 1803.

A new species of Pithecolobium

Pithecolobium Abbottii Rose & Leonard, sp. nov.

Large tree, the younger branches densely brown-tomentose, unarmed; petioles 2 mm. long, brown-tomentose, glandular, the rachis 2 to 7 cm. long, brown-tomentose, glabrescent; pinnae 4 to 6 pairs, 1.5 to 4 cm. long, the leaflets 6 to 8 pairs, obovate or elliptic, 3 to 8 mm. long, 2 to 5 mm. broad, rounded and often shallowly emarginate at apex, narrowed or rounded at base, subsessile, chartaceous, convex, glabrous except for a small tuft of brownish

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 19, 1927.

hairs at base on the under surface, drying greenish-brown above, pale beneath, the venation obscure; inflorescence capitate, the heads globose, the pedicels 2.5 to 4 cm. long, glabrous or nearly so; calyx campanulate, 1.5 mm. long, glabrous; corolla 5.5 mm. long, the lobes narrowly elliptic, acutish, puberulent at apex, about half as long as the tube; stamens numerous, long-exserted, the tube about half as long as the corolla; fruit up to 10 cm. long, strongly curved, contorted after dehiscence, the valves 5 to 8 mm. wide, firm; seeds not seen.

Type in the U. S. National Herbarium, no. 1,079,252, collected near San Lorenzo Bay, on the south coast of Samaná Bay, Dominican Republic, April 29, 1922, by W. L. Abbott (no. 2258).

This species is nearest to *P. oppositifolia* Urban, differing chiefly in its fewer, glabrous leaflets and shorter pinnae.

REVISION OF THE GENUS MIMOSA IN HISPANIOLA

KEY TO THE SPECIES

Valves of the pod not jointed; leaflets large, obliquely obovate. **1. M. ceratonia.**

Valves of the pod several-jointed; leaflets small, oblong, linear or nearly orbicular.

Erect or scandent shrubs; pods unarmed.

Petioles flat.

Pinnae 2 or 3 pairs, 5 to 12 mm. long..... **2. M. Leonardii.**

Pinnae a single pair, vestigial, often lacking; phyllodia leaf-like. **3. M. extranea.**

Petioles terete or channeled.

Leaflets linear, 0.5 to 1 mm. broad; pods 4 to 5 mm. broad. **4. M. domingensis.**

Leaflets oblong, 2 to 3 mm. broad; pods 8 to 10 mm. broad. **5. M. mornicola.**

Prostrate herbs or clambering vines (sometimes woody at base); pods armed with slender setae.

Branches not prickly; valves of pod naked..... **6. M. pudica.**

Branches prickly; valves of pod setose..... **7. M. invisa.**

1. MIMOSA CERATONIA L. Sp. Pl. 523. 1753

Acacia ceratonia Willd. Sp. Pl. 4: 1091. 1805.

Lomophis ceratonia Raf. Sylv. Tellur. 118. 1838.

Slender, trailing or climbing vine, up to 6 meters long (sometimes shrubby); stems glabrous, angular, armed with flat prickles about 1.5 mm. long; stipules subulate, 2 to 3 mm. long; petioles and rachises together 8 to 12 cm. long, armed with sharp curved prickles 1 mm. long, glabrous; pinnae 1 to 5 pairs, the rachilla slender and armed with small curved prickles; petiolules about 1 mm. long; leaflets 3 to 5 pairs, obliquely obovate, 1 to 1.5 cm. long, 5 to 13 mm. broad, rounded at both ends, thin, glabrous, paler beneath, 3-nerved; heads numerous, in terminal racemes or narrow panicles, or few and in the axils of the upper leaves, globular, 10 to 12 mm. in diameter, white or pinkish; peduncles 1 to 2 cm. long, prickly; calyx 0.75 mm. long, the lobes triangular, unequal; corolla 2 mm. long, the lobes usually 3, elliptic, obtusish, 1 mm. long; stamens usually 6, 5 to 6 mm. long; pod oblong, straight or slightly curved, 3 to 5 cm. long, 12 to 15 mm. broad, flat, thin, glabrous, shining, not

jointed, the margins armed with flat hooked prickles 2 to 2.5 mm. long; seeds dull, flat, oval, 5 mm. long, 3 mm. broad, glabrous, 7 or 8 in each pod.

Type locality: Tropical America, perhaps the West Indies.

Distribution: Hispaniola to St. Vincent.

Specimens examined:

DOMINICAN REPUBLIC: In clearing, vicinity of Laguna, Samaná Peninsula, *Abbott* 399. Common creeper in secondary growth, Laguna, *Abbott* 430. Vicinity of Samaná, *Abbott* 476. Without locality, *Wright, Parry & Brummel* 66.

A well marked species, easily distinguished by its large leaves and broad, not jointed pods.

2. **Mimosa Leonardii** Britt. & Rose, sp. nov.

Low shrub; twigs slender, gray, terete, glabrous or the younger minutely puberulent; prickles paired, infrastipular, reflexed, 3 to 4 mm. long, very sharp; petiole, rachis, and rachilla strongly flattened, channeled above, glabrous, armed with small, single or paired, sharp, recurved prickles, the petiole with rachis 3 to 6 cm. long; pinnae 2 or 3 pairs, widely separated; leaflets 1 to 3 pairs, oblong, 4 to 8 mm. long, 2 to 4 mm. broad, rounded at apex, round and oblique at base, thick, entire, glabrous; veins and midrib obscure, the pair of lateral veins joining the midrib at base; peduncles axillary, single or in clusters, 8 mm. long or less, puberulent; flowers sessile, in heads 6 to 7 mm. broad, pinkish; calyx 0.5 mm. long, 4-lobed, the lobes low, blunt, minutely ciliolate; corolla 1.75 mm. long, the tube narrowly campanulate, the lobes 4, erect, oval, acutish at apex; stamens 5 to 8, the filaments glabrous, 2.5 to 4 mm. long, the anthers oval, 0.5 mm. long; ovary 1.25 mm. long, pubescent; pod 4 to 5 cm. long, 6 to 8 mm. broad, flat, curved, the margins thickened, 8 to 10-jointed, the joints square, glabrous, purplish; seeds orbicular, flat, 2.5 mm. in diameter.

Type in the U. S. National Herbarium, no. 1,300,376, collected on a dry bank of the Puilboreau Road near Ennery, Haiti, altitude 350 meters, January 22, 1926, by E. C. Leonard (no. 9105).

This species is a very distinct one, easily recognized among the other West Indian mimosas by the armed, flattened petioles and rachises.

3. MIMOSA EXTRANEA Benth. Trans. Linn. Soc. Bot. **30**: 433. 1875

Slender unarmed shrub up to 3 meters high; branches erect or ascending, reddish brown, glabrous, the younger ridged, the ridges extending in 3's from the bases of the phyllodia; stipules not seen; phyllodia linear, 3 to 6 cm. long, 2 to 5 mm. broad, obtuse at apex, narrowed at base, firm, dark green, prominently 3-nerved, often without leaflets; pinnae minute, 1 pair at the tip of the phyllodium, each with a single pair of leaflets; leaflets nearly orbicular, 1 mm. in diameter; inflorescence a terminal panicle, the flowers capitate, numerous; peduncles 1 to 2 cm. long, puberulent; heads globose, about 8 mm. in diameter at flowering; calyx 0.75 mm. long, the lobes 4, triangular; corolla 3 mm. long, funnelform, the lobes 4, elliptic, 1 mm. long, obtusish, pink at tip; stamens usually 6, 4 to 5 mm. long; ovary pubescent; style equaling the stamens; pods 3 to 4 cm. long, 5 to 6 mm. broad, 5 to 8-jointed, slightly constricted at the joints, flat, reddish brown, seeds flat, 3.5 mm. long, 3 mm. broad.

Type locality: Santo Domingo.

Specimens examined:

HAITI: Puilboreau Road in vicinity of Ennery, Département de l'Artibonite, *Leonard* 8815, 8828, 8882. Between Gonaives and La Hotte Rochés, *Nash & Taylor* 1548.

This is the only species of *Mimosa* with well developed phyllodia.

4. MIMOSA DOMINGENSIS (Bertero) Benth. Journ. Bot. Hook. 4: 409. 1842

Acacia domingensis Bertero; A. DC. Prodr. 2: 464. 1825.
Mimosa diplacantha Benth. Trans. Linn. Soc. Bot. 30: 424. 1875.

Shrub; twigs branching, the older terete, gray, the younger obscurely angled, reddish, glabrous, sparingly armed with small curved prickles; stipules linear, spinelike, 1 to 2 mm. long; petioles with rachis 2 to 5 cm. long, pulvinate at base, armed at the insertion of the pinnae with a pair of curved prickles; pinnae 1 or 2 pairs, pulvinate, channeled above, 1 to 1.5 cm. long, unarmed or bearing an occasional curved prickle; leaflets 7 to 10 pairs, the lower pair reduced to minute scales, the remainder sessile on a minute pulvinus, linear-oblong, 3 to 5 mm. long, 0.5 to 1 mm. broad, rounded at both ends, oblique at base, firm, glabrous, obscurely 3-nerved; flowers capitate, borne in the axils of the upper leaves; peduncles elongating to 3 cm., puberulent and glandular, reddish; heads ovoid, about 10 mm. long and 18 mm. broad at flowering, pink; calyx 1 mm. long, the lobes minute, triangular; corolla 2.5 cm. long, the lobes 4, triangular-ovate, 0.75 mm. long, acutish; stamens 8, 4 to 5 mm. long, the filaments tapering at tips, the style slightly exceeding the stamens, the stigma minute; pods 2.5 to 3 cm. long, 4 to 5 mm. broad, 5 to 7-jointed, slightly constricted at the joints, flat, glabrous, reddish, acuminate at tip, narrowed at base; seeds blackish, flat, nearly orbicular, 2.5 mm. in diameter, glabrous.

Type locality: Santo Domingo, the type collected by Bertero.

Specimen examined:

DOMINICAN REPUBLIC: Azua, *Rose, Fitch & Russell* 4018.

Mimosa domingensis is a well marked species, distinguished by its linear leaflets. The well developed pulvini indicate that the plant is sensitive.

5. MIMOSA MORNICOLA Urb. Symb. Ant. 7: 228. 1912

Scandent shrub; twigs armed with curved spines 2 mm. long, the young branches minutely white-puberulent, often unarmed, the petioles decurrent in 3 parallel blackish costae, the intercostal areas brown; stipules filiform, 3 to 9 mm. long, subulate, more or less curved; leaves 4 to 7 cm. long, with 4 to 9 pairs of pinnae, the rachis and rachillae grooved and minutely pubescent above, armed (in the older leaves) with 2 or 3 infrastipular curved prickles, the pinnae 1.5 to 2.5 cm. long, rather strongly curved, terminated by a pair of curved prickles 1.5 mm. long, the younger leaves unarmed or with a few prickles; leaflets 6 to 9 pairs, becoming black or brown when dry, the first pair reduced to minute subulate scales, the remainder oblong, 4 to 6 mm. long, 2 to 3 mm. broad, rounded or broadly obtuse at apex, obliquely truncate or subcordate at base, entire, glabrous on both surfaces, the midrib obscure above, prominent beneath; inflorescence paniculate, 10 cm. long, minutely puberulent; flowers numerous, in ovoid-globose heads 4 to 6 mm. long; calyx 1 mm. long, 4-lobed, the lobes triangular; corolla funnelform, 1.5 to 1.8 mm. long, the lobes triangular-ovate; stamens 4 to 9, the filaments about 3 mm. long; ovary elliptic, villous; pods 5 to 6 cm. long, 8 to 10 mm. broad, 5 to 7-jointed, minutely puberulent, the margins undulate; seeds flat, nearly orbicular, 4 mm. in diameter.

Type locality: Morne Bonpère, Haiti. Type collected by Buch (no. 685).
Specimens examined:
HAITI: Morne Bonpère, *Buch* 685 (photograph and fragment of leaf). Bank of stream, l'Atalaye Plantation, vicinity of St. Michel, *Leonard* 7014.
DOMINICAN REPUBLIC: Azua, *Rose, Fitch & Russell* 3994. Nigua, *Faris* 447.

A good deal of variation is shown by the specimens cited. Faris's no. 447 from Nigua is a flowering twig with the facies of the type, but differing in its armed leaves and greater number of pinnae (8 to 10 pairs), and also in its more numerous leaflets (8 or 9 pairs on each pinna) and stamens (6 to 9). The type of *M. mornicola* is described as an unarmed shrub with not more than 8 pairs of pinnae, each with 7 or fewer pairs of leaflets, and flowers with but 4 or 5 stamens. Mature twigs with fruit, represented by Rose, Fitch and Russell's no. 3994 and Leonard's 7014, have both stem and leaves armed with sharp prickles. These differences are probably due to the age of the twig and variable environmental factors. The Azua specimen differs further in the slightly larger leaflets, which are broader in proportion than those of the other plants examined.

6. MIMOSA PUDICA L. Sp. Pl. 518. 1753

Mimosa pudica glabrata A. DC. Prodr. 2: 426. 1825.

Herbaceous, or woody at base, branched, usually prostrate, up to 5 dm. long, the stems armed with flat, straight or slightly curved prickles 1 to 4 mm. long, hispid, hirsute, or glabrate; stipules lanceolate, acuminate, 3 to 6 mm. long, striate, hirsute, glabrate, sometimes ciliate; petioles slender, 1 to 6 cm. long, pulvinate at base, deflexing when touched, hirsute or glabrate, often more or less finely puberulent above; pinnae 1 or 2 pairs (when 2, the pairs approximate), 1 to 6 cm. long, hirsute or glabrate, pulvinate at base, the pulvinus and channeled upper surface finely pubescent; first pair of leaflets borne at the summit of the pulvinus, reduced to small linear spreading bracts about 1 mm. long; normal leaflets 15 to 25 pairs, narrowly oblong, 3 to 10 mm. long, 1.5 to 2 mm. broad, acutish or obtuse at apex, oblique and rounded at base, thin, glabrous above, sparingly strigose beneath, meeting above in pairs when touched; heads ovoid, 8 to 10 mm. long, pink or purplish, axillary; peduncles 1 to 3 cm. long, glabrous or sparingly hirsute; bracts obovate or oblong, 0.5 to 0.75 mm. long, acutish, the lowermost ciliate; calyx minute, the lobes unequal, awnlike; corolla funnelform, about 2 mm. long, the lobes 4, nearly 1.5 mm. long, obtusish; stamens 4, long-exerted, pink or white; pods numerous, crowded in a head, linear-oblong, 1 to 1.5 cm. long, 3 to 4 mm. broad, 2 to 5-jointed, constricted at the joints, the sides glabrous, the margins prickly-hispid; seeds brown, flat, nearly orbicular, 2.5 mm. in diameter.

Type locality: Brazil.
Distribution: West Indies and continental tropical America.
Specimens examined:
HAITI: Open mountain slope, Furcy, *Leonard* 4290. Along small stream, Mt. La Cidre, *Leonard* 7536. Meadow, Dondon, *Leonard* 8589, 8657. Roadside, Plaisance, *Leonard* 9179. Meadow, Pilate, *Leonard* 9588. River bank, Gros Morne, *Leonard* 9894.
DOMINICAN REPUBLIC: Wet meadow along railroad, Sánchez, Samaná

Peninsula, *Abbott* 14. Haina, *Faris* 39, 159. Sánchez, *Rose, Fitch & Russell* 4352. Without locality, *Wright, Parry & Brummel.*

This is the common sensitive plant of tropical America, so called because it responds to irritation by a rapid drooping of the petioles and folding together of opposed leaflets. The plants are often found in this "sleeping" condition in the early morning, but gradually expand as warmed by the rising sun. Under cultivation the plant often becomes robust and assumes an erect position. Its common name in the Dominican Republic is morir-vivir; in northern Haiti it is called ronté.

7. MIMOSA INVISA Mart. Herb. Fl. Bras. 121. 1837

Schrankia brachycarpa Benth. Journ. Bot. Hook. **2**: 130. 1840.
Mimosa diplotricha Wright in Sauv. Pl. Cub. 34. 1873.

A herbaceous clambering vine 1 to 2 m. long, the branches angled with numerous reflexed prickles, pilose when young; pinnae 4 to 8 pairs; leaflets many pairs, oblong-linear, 3 to 4 mm. long, glabrous on both sides, ciliate; flowers in dense heads; calyx and corolla glabrous; stamens twice as many as the petals, purplish; pods linear-oblong, 1 to 2 cm. long, setose on the valves and margin, more or less pubescent.

Type locality: Rio de Janeiro, Brazil.

Distribution: Brazil, north to Mexico and the West Indies.

Specimen examined:

HAITI: In meadow at sea-level, near Port Margot, *Nash* 303.

The type of *M. invisa* from Brazil has not been examined. It is possible that the common North American plant which has long passed under this name is specifically distinct.

EXCLUDED SPECIES

MIMOSA ANGUSTIFOLIA Lam. Encycl. **1**: 12. 1783

Erect tree; bark brown or grayish; wood white and very strong; leaves with 4 or 5 pairs of pinnae each bearing from 30 to 50 pairs of narrow leaflets, these green above and pale beneath; flowers racemose; pods 10 to 13 cm. long, 6 to 8 mm. broad, appressed, yellowish; seeds small, orbicular, usually 12 in each pod.

Type locality: Santo Domingo.

Plant not seen. The racemose inflorescence and long, nonjointed pods are characteristic of the genus *Acacia*, to which this species, probably, should be referred.

ARCHEOLOGY.—*Potsherds from Choctaw village sites in Mississippi.*[1] HENRY B. COLLINS, JR., U. S. National Museum. (Communicated by D. I. BUSHNELL, JR.)

Archeological research in the southeastern states can probably never reach the point of exactness that it has in the Southwest. There are

[1] Published by permission of the Bureau of American Ethnology, Smithsonian Institution. Received April 12, 1927.

no stone ruins, and barring a few exceptional kitchen-middens along the coasts, no extensive refuse heaps showing successive culture layers. The climate, furthermore, is not such as to preserve textiles, basketry, wood-work or other perishable objects so that about all that is now left of the once high material culture of the Southern tribes is the pottery and the ornaments and implements of stone, shell, and bone. It is very desirable, therefore, to seize upon every available source of tribal identification of the cultures represented, and to accomplish this end there is probably no safer beginning than to locate the historic Indian village sites and to study their type of cultural remains for comparison with other sites of unknown age. This method was followed during the past two summers when for several months the writer carried on preliminary archeological work in Mississippi for the Bureau of American Ethnology in coöperation with the Mississippi Department of Archives and History, represented by Mr. H. H. Knoblock.[2]

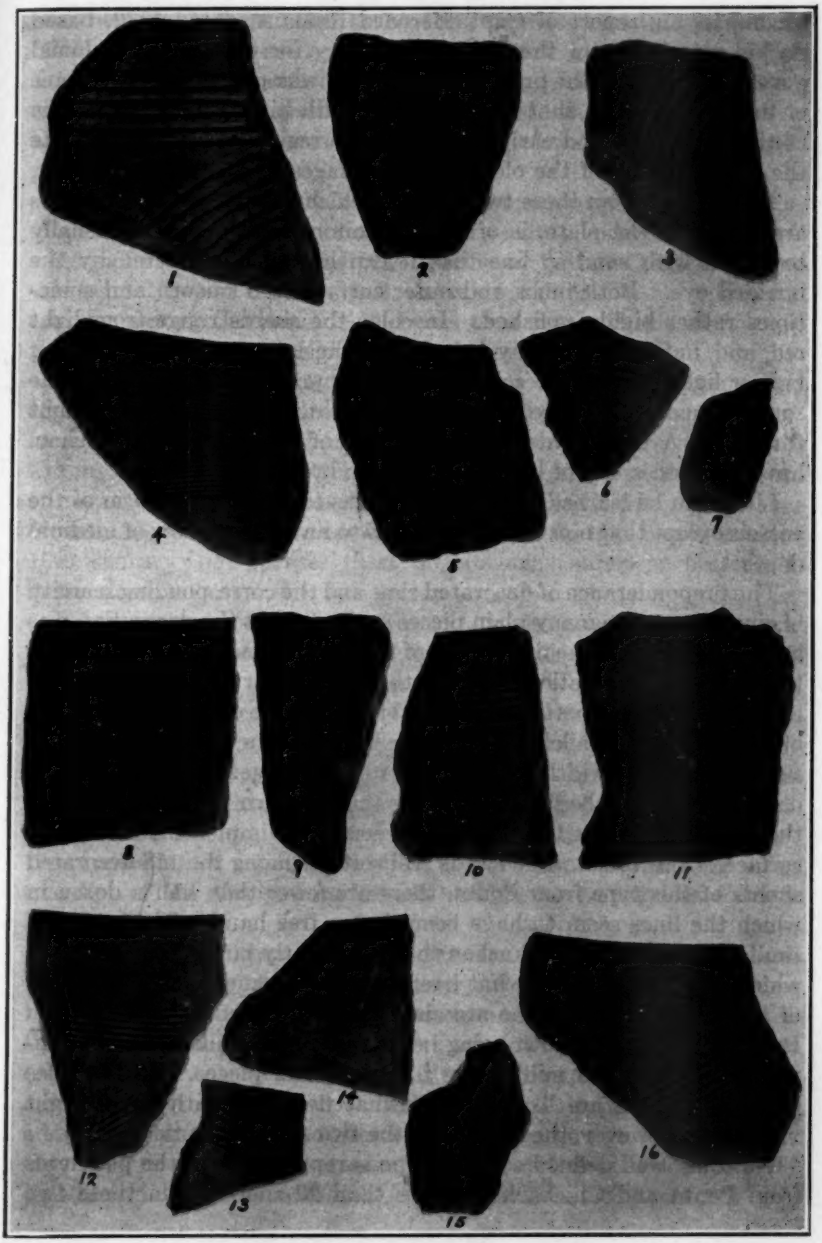
The region chosen for investigation was the east central section of the state, the former home of the Choctaw. A brief reconnoissance of this area was first made and a number of mounds and Choctaw village sites were located and later explored. Wherever possible, surface collections of potsherds, flint artifacts, etc., were made. It is to such collections of potsherds that attention is here called, for these seem to indicate that there was a definite type of historic Choctaw pottery, entirely distinct from that of any other region.

In the accompanying plate are shown examples of this type of pottery from the sites of two old Choctaw villages, Chickachae in the northeastern part of Clarke County, and Ponta (Coosa) in northern Lauderdale County. According to Prof. H. S. Halbert, who worked for many years among the Choctaw in Mississippi, Ponta was occupied as late as 1846.[3] The time of the abandonment of Chickachae is not definitely known but it probably took place between 1810 and 1834, during which period the greater part of the Choctaw lands were signed away and their former owners forced to migrate west of the Mississippi River. The first reference to Ponta and Chickachae is found in the manuscript journal of Régis du Roullet, the French army officer, who in 1729 made the first official exploration of the Choctaw country.[4] The two villages again appear on the map and in the

[2] *Archeological and anthropometrical work in Mississippi.* Smithsonian Misc. Coll. 78 (1). 1926.

[3] *Bernard Romans' map of 1772.* Publ. Miss. Hist. Soc. 6: 415–439.

[4] In Mississippi Department of Archives and History and in Manuscript Division of the Library of Congress.



Figs. 1–7. Potsherds from site of Chickachae, old Choctaw village in northeastern Clarke Co., Miss. Figs. 8–16. Potsherds from site of Ponta, Northern Lauderdale Co., Miss.

accompanying report of Capt. Bernard Romans, dated 1772, based on his exploration of the Choctaw country for the English colonial government during the preceding year. It was principally by means of the Romans map that Prof. Halbert, with his intimate knowledge of the geography and early history of the region, was able to locate the sites of many of the old Choctaw villages.

The pottery from these two sites, of which typical decorated pieces are shown in the plate, is of a hard uniform texture and is usually tempered with sand so fine that it can hardly be detected by the unaided eye. Both inner and outer surfaces are smooth and sometimes rather highly polished. In color the sherds range from light red and buff through gray into black, the largest proportion being buff or light gray. The color was usually produced by polishing the surface, merely intensifying the shade to which the firing had brought the clay. A few sherds, however, most of them from Chickachae, have received a slip of light brick red on both surfaces.

Little can be learned from the sherds as to the original form of the vessels except that most of them appear to have been bowls of medium depth.

The preponderance of decorated rims and the corresponding scarcity of rims among the many plain pieces suggests that the decoration was largely confined to the upper part of the vessel. As may be seen from the plate, this decoration, which is the most important and characteristic feature of the pottery, consists of straight or curved bands made of finely incised parallel lines. These bands, formed usually by five or six lines, range in width from about 5 to 10 millimeters. The uniform distance between the lines, as well as their uniform depth, shows that they were made by trailing a fine, comb-like implement across the surface of the vessel while it was still soft. Among the 118 decorated sherds of this type from Ponta, there are fewer than half a dozen in which the lines seem to have been drawn free hand. The lot of 67 similar sherds from Chickachae shows a slightly larger proportion on which the lines are somewhat irregular. The bands on the majority of sherds from Chickachae are also a little broader than those from Ponta, the average width being between 8 and 9 millimeters as compared with about 6 millimeters for the Ponta pieces, and the lines composing them are likewise somewhat deeper. With these slight variations, however, the ware from the two sites is identical.

No other well defined ceramic type is represented in the potsherds from Ponta and Chickachae. Less than 20 sherds from these two

sites bear decorations other than of the type described: these few are of cruder ware and are meagerly ornamented with irregular incised lines. There is, in addition, comparatively little undecorated ware of a cruder type; the greater part of the plain sherds, of which there are many, are of the same smooth compact ware as the decorated pieces.

The potsherds from Chickachae and Ponta represent the only adequate samples that were obtained. Very scanty collections of sherds were picked up on the sites of Yowanne in Wayne County, Okhata talaya in Newton County, and Halunlawasha in Neshoba County, and yet among the handful of sherds thus obtained one or more of the banded type was found at each of the three places.

The presence of this single type of decorated ware from such widely separated Choctaw settlements, covering the entire area known to have been occupied by that tribe, suggests very strongly that it was the prevailing type of pottery in use at some period of their history. It may safely be regarded as historic, in the sense that it is found thus far only at Choctaw sites known to have been occupied as late as the 19th century, but further than this its age cannot at present be determined.

In texture and color this Choctaw pottery is similar to a widespread type from the mounds in western and central Mississippi and in parts of Arkansas and Louisiana. It is strikingly different, however, from the prevailing type of mound pottery from eastern Mississippi. The pottery from the mounds of this section is usually rough and crumbly and contains rather coarse tempering material. The decorations most often found are produced either by "brushing" or by impressing cords or coarse fabrics on the soft surface. Sometimes there is an ornamentation consisting of carelessly incised lines or punctations, and, infrequently, of the stamped curvilinear designs so common in Georgia and Florida.

It is too early to speculate, on the basis of this ceramic distribution, as to whether this Choctaw pottery developed locally or whether it had its origin to the west. Consideration of this question, as well as that of a possible earlier occupancy of the Choctaw territory by some other tribe, must be deferred until more complete information is available. It would be very desirable, for this purpose, to have additional collections of potsherds from other known Choctaw village sites and from the little known mounds and unidentified sites of central and western Mississippi.

RADIOTELEGRAPHY.—*Experimental confirmation of the influence of a low-resistivity layer subsoil on the forward inclination of radio waves.* J. E. I. CAIRNS, Watheroo Magnetic Observatory, Department of Terrestrial Magnetism, Carnegie Institution of Washington. (Communicated by LOUIS A. BAUER.)

On the conclusion of the resistivity-survey of the region about the Watheroo Magnetic Observatory, at the end of June 1926, it was seen that the characteristics of the terrain were such as to afford means of experimental confirmation, or otherwise, of the suggestion, first put forward by Hack,[1] that ground-water (or a low-resistivity layer), at a depth of a fraction of a wave-length below the ground-surface, would almost entirely annul the "forward" inclination experienced by radio waves when travelling over ground of considerable resistivity. The survey at Watheroo showed the surface layer, down to depths varying from 5 to 10 meters, of the sand-plain which comprises the greater part of the surrounding country, to be of very high mean resistivity, falling off rapidly below this surface layer to value less than one-tenth per cent of that at the surface at depths of 60 meters in most cases. At one place, about 2 miles east of the Observatory, the low-resistivity layer breaks through to the surface, the resistivity down to 100 meters being less than 400 ohms per centimeter cube.

Thus the conditions were admirably suitable. Although Hack had shown previously that the inclination would be annulled, measurements of resistivity of undisturbed soil were not at that time available. These measurements, at Watheroo were made at low frequency (approximately 60 cycles), and the results are accurate to within one per cent.[2]

Two sites only were selected for the measurements, namely, at the places of highest and lowest resistivities, respectively, upon the conclusion of the survey. The highest was at the mid-point of the "survey line *P*" about three-quarters mile due north of the Observatory, and had a mean value down to 5 meters depth of approximately, 1,500,000 ohms per centimeter cube. The point of lowest resistivity was selected principally to test the accuracy of the apparatus, since it was of such low value down to a depth of 100 meters, that the inclination must have been negligible. The variations of resistivity with depth at the point *P* and for mid-point of section *e*, line 2 (the low-resistivity spot) are given in Table 1. At *P* the ground sloped

[1] J. ZENNECK, *Wireless Telegraphy* (English Translation), pp. 260–262, 1915.
[2] L. H. GISH and W. J. ROONEY, Terr. Mag., **30**, 161–188, 1925.

backwards towards the transmitter at an angle of about one-quarter degree (measured roughly with a theodolite), while at section *e*, line 2, the surface sloped away from the transmitter at an angle of 1.3 degree. Observations were made on one station only, 6*WF* (wave

TABLE 1.—VARIATIONS OF MEAN RESISTIVITY WITH DEPTHS AT WATHEROO MAGNETIC OBSERVATORY

DEPTH	MEAN RESISTIVITY FOR POINT	
	P	Mid-point section *e*, line 2
m	*ohms per cm. cube*	*ohms per cm. cube*
2.5	1,016,000	351
5	1,417,000	236
10	954,500	205
20	214,000	223
30	35,000	224
60	1,480	256
100	.....	310

length 1,250 meters), since the times of transmission from this station were definitely known. The Observatory is almost exactly due north of the transmitter, and 132 miles from it.

APPARATUS

The apparatus consisted of a portable Hertzian rod oscillator, mounted on the telescope of a theodolite, and connected to a screened five-valve receiver by leads passing through a thick iron tube. The rod was 7 feet above ground when set up for measurements. The rod consisted of two five-foot lengths of thin wood joined by ebonite strips and stayed at the ends by strings passing to a king-post at the center. Upon the rod, the wire forming the aerial was strained, and tied at intervals with thread to prevent movement relative to the rod itself. The straining of the rod introduced a slight bend, thus inserting a small component of the oscillator normal to its length; the means for eliminating the effect of this are described below. The screening was effective enough to reduce the stray pick-up to zero, and the effects due to the unsymmetrical capacities of the individual halves of the rod were reduced considerably by means of a partial ground to the mid-point of the oscillator-system, as described by Greenleaf W. Pickard.[3] The oscillator was mounted on the top of

[3] GREENLEAF W. PICKARD, The Polarization of Radio Waves, Inst. Radio Engineers, 1925.

the screening box containing the receiver, and the observer stood on another box at the center, immediately opposite to the lead-in tube. The ground was cleared for a distance of at least 15 feet all round the point where observations were being made. The receiver was caused to oscillate, thus giving a heterodyne note with the carrier of the received wave. The circuit employed is shown in Figure 1.

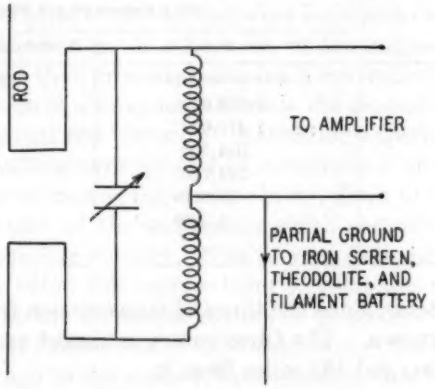


Fig. 1.—Diagrammatic sketch of set-up

METHOD OF OBSERVATION

The two halves of the oscillator were not in the same straight line, so that the procedure for observation had to be devised to eliminate the effect due to the fixed component of the rod normal to its length. A short length of the leads also, about 3 inches, was unscreened, so that the procedure had to include means for eliminating the pick-up which these introduced. One side of the rod was marked *Up*, the other *Down*, one lead was marked *N*, and when *N* was connected to the north terminal of the rod, the arrangement was termed *Position A*; when *N* was connected to the south terminal, the arrangement was called *Position B*. The schedule for a single observation then was:

(I) Rod *Up*—(1) position *A*, vertical circle east; (2) position *B*, vertical circle east; (3) position *B*, vertical circle west; (4) position *A*, vertical circle west.

(II) Rod *Down*—(1) position *A*, vertical circle west; (2) position *B*, vertical circle west; (3) position *B*, vertical circle east; (4) position *A*, vertical circle east.

By this method of complete reversal, the results should be free from the spurious effects due to imperfections in the oscillator and lack of symmetry, stray pick-up, and incorrect setting of the horizontal circle on the bearing of the transmitter. In the case of the observations at P, 20 readings were made for each combination, to obtain a fairly reliable mean, then 20 on the next, and so forth. A slightly variable factor was introduced by the wind, which during both sets of readings was blowing from the west, and causing the rod to vibrate considerably. This caused, on occasions, a noticeable blurring of the minima.

TABLE 2.—RESULTS OF OBSERVATIONS AT WATHEROO MAGNETIC OBSERVATORY ON STATION 6WF TRANSMITTING AT WAVE-LENGTH 1,250 METERS

LOCATION	ROD, POSITION, VERTICAL CIRCLE	NO. OF OBS'NS	INCLINATION	INCL'N TO VERTICAL	TRANSMISSION	GROUND LEVEL	INCL'N TO SURFACE
			°	°		°	°
Res.-survey line P	*Up, A, E*	20	+7.6				
	Up, B, E	20	−7.2				
	Up, B, W	20	−9.6				
	Up, A, W	20	+6.6	−0.6	Night	+0.2	−0.4
	Down, A, W	20	+8.6				
	Down, B, W	20	−7.6				
	Down, B, E	20	−9.5				
	Down, A, E	20	+6.6				
Middle section *e*, res.-survey line 2	*Up, A, E*	10	+6.8				
	Up, B, E	10	−8.1				
	Up, B, W	10	−8.2				
	Up, A, W	10	+10.1	+0.6	Day	+1.3	−0.7
	Down, A, W	10	+11.3				
	Down, B, W	10	−5.6				
	Down, B, E	10	−9.4				
	Down, A, E	10	+7.7				

It is shown[4] that the ratio of the horizontal to the vertical-electric force, on Zenneck's theory, is given by the formula

$$\frac{E}{X} = \sqrt{\frac{m}{\sqrt{1+m_1^2}}} = \tan \beta \qquad (1)$$

where $m = nk\,\rho/2 \times 10^{11}$, $m_1 = nk_1\,\rho/2 \times 10^{11}$, and n = frequency, k = dielectric constant of air, k^1 = dielectric constant of the soil, ρ = resistivity in ohms per centimeter cube, and β = the angle of the forward inclination of the wave-front to the normal. When the

[4] J. A. FLEMING, *The Principles of Electric Wave Telegraphy and Telephony*, 4th edition, 1919.

rod makes the same angle with the horizontal as the wave-front does with the normal to the ground, no sound is heard in the telephones. The rod was rotated, therefore, about its horizontal axis, with its long axis normal to the wave-front, until a minimum was heard.

RESULTS OF OBSERVATIONS

The results of the observations are shown in Table 2. The maximum departure from the mean of the readings in any one set was 4°, and that on one occasion only. In general, the departures were 2° or less, and the mean may be taken as accurate to 1°.

DISCUSSION OF RESULTS

In each case, the resultant inclination to the ground normal is seen to be negative, and this, if real, is most probably due to two causes: (1) The vibration of the rod caused by the wind; and (2) the fact that the minima in the positions giving negative inclination were sharper

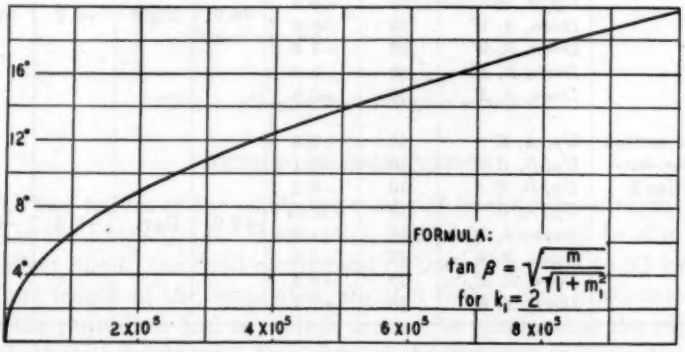


Fig. 2.—Plot of wave-front angle of forward inclination in degrees for wavelength = 1250 meters against resistivity in ohms per centimeter cube.

than in the positive positions. In any case, the resultant inclination is less than the accuracy of the mean readings, and it may be taken, therefore, that it is either zero or negligible. From an inspection of Figure 2, which is plotted from values computed according to formula (1), assuming a value for the dielectric constant of the soil as 2 (the value of k_1 has little effect on the value for tan β), it will be seen that if the surface layer alone were concerned in the conduction of the wave, an inclination of the order of 20° should have been observed at P and none at all at section e, line 2. From the circumstance that

no inclination was observed in either instance, it is evident that the low-resistivity layer below the surface is sufficient to entirely annul the forward inclination of radio waves, at least those of wave-length 1,250 meters. Moreover, from Table 1, it may be deduced that the mean depth to which waves of this wave-length penetrate, is at least 45 meters, for at that depth, the mean resistivity at P is such as to give a forward inclination of 1°.

SUMMARY

Over soil, the mean resistivity of which had been measured *in situ* down to depths of 60 to 100 meters, and which consisted of a layer of sand of an exceptionally high resistivity over a layer at no considerable depth of very low resistivity, radio waves of wave-length 1,250 meters were found to experience no forward inclination. This is regarded as being more definite proof than has hitherto been given of the effect of ground-water or a low-resistivity layer a short distance below the surface, owing to the greater precision of the resistivity measurements of the undisturbed soil.

I wish to express appreciation of the interest shown and the facilities given by Mr. H. F. Johnston, Observer-in-Charge at the Watheroo Magnetic Observatory; also thanks to Observer Mr. F. W. Wood for material assistance in transporting apparatus and recording, and to Mr. W. J. Rooney, who made the resistivity-survey of the region for the resistivity-values at the two points of observation in advance of publication.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

948TH MEETING

The 948th meeting was held at the Cosmos Club, January 8, 1927. The address of the evening was given by the retiring president, WILLIAM BOWIE, on *The part played by isostasy in geophysics and geology.* (Published in the JOURNAL, 17: 101-117, March 4, 1927).

949TH MEETING

949th meeting was held at the Cosmos Club, January 22, 1927.

Program: R. L. SANFORD, *The problem of magnetic analysis.* The idea that the magnetic properties of iron and steel can be used as criteria of their mechanical properties has been the subject of speculation and experiment for more than forty years. In view of the fact that the application of this

idea, which has been termed magnetic analysis, is still in the experimental stage, it seems desirable to consider what progress has been made, to ask ourselves whether further effort is justified, and, if so, along what line investigation should be directed.

New testing methods have been developed, making possible much investigational work that otherwise could not have been done. The large mass of data which has been obtained indicates a close connection between the magnetic and mechanical properties of steel.

No positive evidence has yet been obtained to controvert the idea that there is a definite relation between magnetic and mechanical properties, and in view of the great need for a practical method for the nondestructive testing of iron and steel and their products further effort in this field appears to be amply justified.

Main attention should be given to fundamental investigation because it is necessary to know the underlying principles in order to realize to the fullest extent the possibilities of magnetic analysis. The greatest obstacle at present is the effect of mechanical strain. Mechanical and magnetic properties are both modified by strain, but not necessarily to a corresponding degree and this factor must be eliminated or evaluated before the fundamental relationships can be discovered. If this can be done the practical application should be a relatively simple matter. (*Author's abstract*).

The paper was discussed by Messrs. WHITE AND HUMPHREYS.

P. R. HEYL, *The constant of gravitation.* The Bureau of Standards has had under way for the past three years a redetermination of the Newtonian constant of gravitation, the quantity k in the formula for the force of attraction between two bodies

$$\text{Force} = \frac{kMn}{D^2}$$

The method used was that of the Cavendish torsion balance, set up in a vacuum. The large attracting masses were placed in two positions, at right angles, and the difference in the time of swing noted. This amounted to about five and a half minutes. The last experimenter who used this method (Karl Braun, 1896) obtained a difference of only about three quarters of a minute.

The programme of observations has been finished, but the calculations are not yet completed. It is expected that the results will be ready to announce in a couple of months. (*Author's abstract*).

The paper was discussed by Messrs. BREIT, WHITE, CURTIS, DRYDEN, PRIEST, WADLEIGH AND CROOK.

H. E. MERWIN, *Recording Secretary.*

THE GEOLOGICAL SOCIETY

427TH MEETING

The 427th meeting was held at the Cosmos Club, March 9, 1927, President BUTTS presiding.

Informal communication: HUGH D. MISER: *Shapes of stream pebbles in San Juan County, Utah.* The question, "Do stream pebbles have any characteristic shape?," has been asked by many geologists. On this question

I here record briefly my observations in the canyon of San Juan River, Utah, in 1921.

Pebbles of many kinds of rocks, including sedimentary and crystalline rocks, and vein materials, constitute the gravel deposits on widely scattered benches in the canyon. The deposits occur at several different levels up to 600 feet above the river, and consist largely of pebbles that have been derived from pre-Cambrian and later rocks in the San Juan Mountains of southwestern Colorado. The pebbles from these mountains have been transported by streams for distances that range from 200 to more than 300 miles. Their shapes, as well as the shapes of the pebbles that are derived from the rocks along or near the Canyon, are the result of stream wear. Such wear is of course influenced by the nature and structure of the pebbles, and the shape of the original rock fragments.

The pebbles are mostly 1 to 3 inches in diameter and most of them are well rounded. The well rounded pebbles consist of quartzite, limestone, gneiss, schist, sandstone, conglomerate, vein quartz, porphyritic igneous rocks, and granitoid igneous rocks. Also the well rounded pebbles contain a considerable proportion of flattened ellipsoids rather than spheres or flattened spheroids. Many platy rocks such as schist and laminated sandstone naturally break into flat fragments and readily yield flattened pebbles when the corners are rounded off. Homogeneous rocks such as granite, andesite and vein quartz might be expected to yield some spherical pebbles, but not a single sphere was observed by me. All pebbles of these and other kinds of homogeneous rocks are flattened. The flattened ellipsoidal form of the pebbles may be due to the original shape of the rock fragments, none of which would likely have equal dimensions as does a cube.

Pebbles that are not well rounded include flint, agate, and chalcedony. I believe their brittleness and also their great hardness are factors that influence their shapes. I believe they may break into large and small fragments at times during their life history.

Many subangular pebbles are bounded by facets which were formed by the breaking of the rock along laminae or other weak planes. Wind-faceted pebbles were not noted by me but some pebbles, especially those of limestone, were furrowed with minute grooves that were produced by sand blasts in the few small areas of dune sand. (*Author's abstract.*)

Program: W. P. WOODRING and P. V. ROUNDY: *Geology and oil development of the Elk Hills, California.* The Elk Hills lie along the southwest edge of the San Joaquin Valley in the outer belt of foothills of the Temblor Range. The only outcropping beds are late Pliocene nonmarine deposits called the Tulare formation. They consist of alternating beds of sand and clay. The sand is clean and arkosic, cross-bedded, and has a complex pattern of gravel courses. The clay is silty and massively bedded, and carries calcareous layers ranging even in the same layer from calcareous clay to limestone. The sands are alluvial fan deposits and the clays seem to be mud-flat and playa deposits. The alternation of these beds at any one place is so perfect and on so large a scale that it demands some kind of periodic control and probably the simplest kind of periodic control is periodic subsidence of the San Joaquin Valley. The oil-bearing beds lie in the upper part of the Etchegoin formation, which underlies the Tulare formation. Immediately above the main oil zone and lying in nonmarine beds is a thin layer carrying some curious fossils, known as *Scalez petrolia.* These fossils are calcareous opercula of freshwater snails similar to living pond snails of the genus *Viviparus*, which,

however, have horny opercula. The *Scalez*-bearing bed is a very reliable datum plane and is used to great advantage by the oil operators.

Structurally the Elk Hills consist of two main gently folded anticlines. Narrow steeply folded anticlines lie along or near the south edge of the hills and also at the northwest edge. These little anticlines probable are very shallow and in some way are the offspring of the main folds, but their origin is not clear.

The main oil zone of the eastern part of the field lies immediately below the *Scalez*-bearing bed. The gas produced in the central part of the field is obtained from beds above this zone. Contours drawn on the *Scalez*-bearing bed show that the dip of the oil-bearing beds is twice as great as the dip of the surface beds. Faults that have a maximum stratigraphic displacement of about 250 feet at the horizon of the oil-bearing beds have not been recognized at the surface. During the last 6½ years the field has produced more than 76,000,000 barrels of oil. (*Authors' abstract.*)

CHARLES W. GILMORE: *Fossil footprints in the Grand Canyon.* Two trips to the Grand Canyon, Arizona, were undertaken for the dual purpose of securing collections of fossil tracks for the U. S. National Museum and preparing an exhibit *in situ* for the National Park Service.

The tracks occur in the Coconino, Hermit, and Supai formations at levels of 1,000, 1,300 and 1760 feet, respectively, below the present rim of the Canyon wall. Both of the projects were successfully carried out, a collection of slabs of footprints some 4,400 pounds in weight were secured for the National collections and a track-covered surface several hundred square feet in area was uncovered by the side of the Hermit Trail in the Coconino sandstone to form a permanent exhibit of the tracks as they occur in nature.

All of the tracks in the Coconino occur on the inclined surfaces of the strong cross-bedding of the sandstone, and all but three of the hundreds of tracks and trails observed were headed up the slope. No satisfactory explanation of this fact has yet been obtained.

Adequate ichnite faunas have now been established for the Coconino and Hermit, and a beginning made on a fauna for the older Supai. In all, 24 genera and 33 species of fossil tracks have now been recognized, distributed as follows: Coconino, 15 genera and 22 species; Hermit, 6 genera and 8 species; Supai, 3 genera and 3 species. Comparison of these faunas shows them to be absolutely distinct from one another as not a single genus is common to any two of the faunas. Both vertebrate and invertebrate animals are represented by these tracks. No skeletal remains have yet been found in the Grand Canyon and consequently no direct evidence can be offered as to the makers of any of these tracks. (*Author's abstract.*)

RAYMOND C. MOORE: *Problems in the History of the Grand Canyon Region.* The unparalleled vertical and horizontal extent of rock exposures in the Grand Canyon region and the clearness with which phenomena relating to almost all branches of geology are represented, have made this territory a classic ground for studies in geologic science. Yet, because of inaccessibility, observations have been essentially confined to a small part of the district. Indeed, excepting John Wesley Powell, the writer is the first geologist who has had opportunity to visit parts of the upper and lower sections of the canyon.

Notwithstanding excellent exposures and the more or less detailed observations of various workers, it is expectable that there are many unsolved problems in the geologic history of the Grand Canyon region. These may be

arranged conveniently in groups: (*a*) those of the stratified rocks, their age, origin, relations to associated formations, regional relations, and the significance of various minor characters; (*b*) those of the igneous rocks, intrusive and extrusive; (*c*) those of the metamorphic rocks, their classification and origin; (*d*) those bearing on the structure of the rocks, its origin, geologic age and effects; and (*e*) those in the field of physiography. Only a few of these problems can be indicated here.

(*a*) The *stratified rocks* include about 4,000 feet of sub-horizontal limestone, sandstone and shale of Paleozoic age, resting unconformably on 12,000 feet of somewhat evenly inclined Proterozoic strata and on Archeozoic rocks. The regional relationships of the Kaibab limestone and Coconino sandstone at the top of the column, the nature and significance of the contact between these formations, and the origin of the Coconino are important problems. The complementary variations in thickness of the Coconino and subjacent Hermit shale, the time represented by the unconformity at the base of the Hermit, the position of the Pennsylvanian-Permian boundary, and the stratigraphic relationships of the Devonian and of the Cambrian formations are largely unsolved problems. The remarkably smooth surface of the pre-Paleozoic rocks beneath the Cambrian, and of Archeozoic rocks beneath the Unkar series, suggests marine planation, possibly supplementing subaerial peneplanation.

(*b*) The *igneous rocks* include great and small intrusive masses of acid, intermediate, and basic rocks in the Archeozoic, mainly basic intrusive and eruptive rocks in the Proterozoic, and basic eruptives of Tertiary and Recent age. The many miles of continuous exposures of Archeozoic igneous rocks afford splendid opportunity for study that is almost untouched. The occurrence in each of the Proterozoic areas of thick diabase sills near the base of the Unkar series recalls the widespread similar rocks in the Proterozoic of other areas and in the Triassic Newark series. The wide geographic distribution and persistence in stratigraphic position of the Grand Canyon diabase call for notice. In comparatively recent time basaltic lava invaded the canyon near Lava Falls, below the mouth of Havasu Creek, and flowed downstream at least seventy miles. Numerous remnants of the narrow canyon-bottom lava flow are found, with even upper surface a little over 100 feet above present river level. The results of temporary damming of the river and the length of the attenuated basaltic flow are interesting subjects of investigation.

(*c*) The *metamorphic rocks* of the Archeozoic have been classed together under the term Vishnu schist. Very much of the schist is undoubtedly of sedimentary origin; in parts of the canyon there are great thicknesses of little altered quartzite and slate. Several types of meta-igneous rocks are found. The differentiation of the Archeozoic complex offers several important problems.

(*d*) The *structure* of the rocks in the Grand Canyon region affords many subjects for study. The structure of the Archeozoic and Proterozoic rocks and its regional relations; the sharp monoclinal folds of post-Cretaceous-pre-Eocene age; the large normal faults of post-Wasatch (Eocene) age; the movements at certain places at different geologic times, in some cases in opposite directions; and the nature, time and causes of regional warping are some of these problems.

(*e*) The *physiography* of the canyon country has long been an alluring field for research, and observations in this region have helped to clarify various

physiographic concepts. The relation of land forms to rock hardness and structure is evident, though the development of some of the characteristic features, such as the amphitheaters, the long narrow spurs and the general pattern of sculpture in parts of the Grand Canyon, have not been obvious. The writer accords with the conclusion of Noble and Matthes that small faults and comparatively unnoticed fractures have played an important rôle in the shaping of the canyon. However, the origin of the canyon as a whole, the location of the course of the river, and the physiographic history of the region offer problems that are largely unsolved. Remnants of peneplains, intrenched meanders and other features bear testimony to a long and probably complex history. The writer's study leads to the conclusion that much erosion in the Grand Canyon area, involving removal of most of the Mesozoic rocks that were once present here, was probably accomplished in pre-Wasatch time; that the river was established in its present course mainly by superposition, following a course that was consequent on Tertiary beds; and that the main stream is influenced by structure near the south end of the Kaibab Plateau, between Diamond Creek and the mouth of the canyon, and perhaps at other places, but seems to be unrelated to the great Tertiary faults which cross the region. Study of Glen Canyon, Marble Gorge, and adjacent parts of the plateau country suggests the existence of a well advanced erosion cycle which was interrupted at a stage when the river had already begun the excavation of the Grand Canyon and had cut downward more than 2,000 feet below the Kaibab rim. Perhaps this earlier erosion cycle corresponds to the "Great Denudation" of Dutton that preceded the stage of active canyon cutting. While the sudden widening of the canyon in the Kaibab division may result from the beginning of erosion here in the earlier erosion cycle, the writer knows of no identifiable remnant of the suggested pre-canyon cycle within the Grand Canyon. Such platforms as the Tonto bench and the Esplanade are structural in origin. It is doubtful whether any remnants of an older valley could be preserved where subsequent downward erosion has been so active.

The distribution of rapids, in almost every case at the mouth of a tributary stream, and the relation of river gradient to rock hardness and other factors of stream erosion are interesting subjects of study. One may conclude that despite numerous rapids, a certain more or less stable relationship has been attained on Colorado River between the rate of erosion and the ability of the river to erode. (*Author's abstract.*)

428TH MEETING

The 428th meeting was held at the Cosmos Club March 23, 1927, President BUTTS presiding. *Program:* T. B. NOLAN: *Potash brines underlying Great Salt Lake Desert, Utah.* During the summer of 1925, the Geological Survey, in coöperation with the Bureau of Mines and the General Land Office, prospected the potash-bearing brines in the Great Salt Lake Desert region. Two types of brine were found: (1) brine contained in the interstices of crystalline salt deposits, and (2) brine found at a definite horizon in clays belonging to the Lake Bonneville beds. The first type of brine is the more concentrated of the two and is believed to represent a residual mother liquor, more or less modified by rain water, that has existed since the final withdrawal of the waters of Lake Bonneville. The horizon at which the second type of brine occurs is thought to be a salt-impregnated zone deposited during the final stage of the earlier desiccation of Lake Bonneville, and would thus be

equivalent to the unconformity found by Gilbert between the Yellow Clay and the White Marl. The brine found is considered as being the result of the introduction of surface drainage waters along this soluble layer. This hypothesis is based upon the following observations: The depth to the brine horizon is a minimum at the center of the Desert and increases to 9 feet at the edge of the prospected area. This compares with a thickness of 10 feet for the White Marl in the type section at the Old River Bed. The clays above and below the brine horizon are sufficiently impermeable that towards the center of the area, where the brines are under a hydrostatic head, a rise of as much as a foot results when the horizon is tapped by a bore hole. Obviously, the brine horizon has some property not possessed by the remainder of the clay. The concentration of sodium chloride in the brine increases towards the center of the area, and the rate of increase was found to vary inversely with the amount of surface drainage waters available. Thus, where large drainage channels enter the prospected region, the chlorine content is notably depressed. Further, the relative amounts of potassium and magnesium in the brine show a striking dependence upon the character of the country rock in the adjacent highlands—potash, for example, being high in the brines where rhyolite flows from the highlands nearby; and magnesium tending to dominate near areas of dolomitic rocks. The calcium sulphate and carbonate, which presumably formed a large part of the mineral content of the indraining surface waters, have been almost entirely precipitated and are represented by a "caliche" or hardpan immediately above the brine horizon.

Deep bore holes put down by one of the operating companies showed the presence of several deeper brine horizons. If these may be interpreted in the same manner as the one prospected, it would seem that the history of the Bonneville Basin is considerably more extensive than has been so far recognized. (*Author's abstract.*)

C. K. WENTWORTH, J. E. HOFFMEISTER, AND H. S. LADD: *Unusual types of sediments from Pacific Islands.* Four types of islands are represented in this study: (1) oceanic islands of volcanic origin such as the Hawaiian groups; (2) oceanic islands without known igneous base such as the coral islands of the Line and Tonga groups; (3) islands like Eua, Tonga, which have a volcanic ash base nearly entirely covered with limestone; and (4) islands like Vitilevu, Fiji, which are partly volcanic but have some continental types of rocks.

(1) In Hawaii the sediments are derived mainly by chemical weathering from basalt and consist of highly ferruginous mantlerock and soil; gravel and ferruginous clays with very little sand; coral reef rock; detrital calcareous sand composed of coral, shell and foraminiferal debris; and pyroclastic rocks and their crystal sand derivatives.

(2) The sediments of the Line Islands, which are wholly of organic origin, are chiefly coral and *Tridacna* gravels and conglomerates; beach sands of coral and molluscan shell debris and foraminifera; and coral muds and silts. Reef formations are the fundamental rocks of the group and the source of the detrital derivatives.

(3) The island of Eua is a representative of the Tongan group. The core of the island is volcanic tuff. This is overlain by younger sediments of various sorts, including a reworked tuff to which much organic material has been added. Foraminiferal and coralline limestones form an extensive series of terraces, and in one locality andesite boulders in a matrix of calcareous sand form a thick deposit of conglomerate.

(4) The dominant sediments of Vitilevu, Fiji, are those belonging to the agglomerate-tuff-marl series, most of which are marine in origin. The marls are usually reworked tuffs to which variable amounts of clay and shelly material have been added. Subordinate rock types include conglomerates, sandstones, and limestones of several sorts, often more or less tuffaceous. Both foraminiferal and coralline limestones occur. Ordinarily these are found as small lenticular bodies in the main series, but two limestone masses, each several hundred feet in thickness, are known. (*Authors' abstract.*)

W. C. ALDEN: *Certain Pliocene and Pleistocene features of Yellowstone Park and its environs.*

W. P. WOODRING, W. W. RUBEY, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Members of the United States Geological Survey on May 2 tendered Dr. GEORGE OTIS SMITH a testimonial luncheon in honor of his completion of 20 years as Director. Dr. SMITH became a member of the Survey in 1896 and was appointed Director in 1907.